NEURAL NETWORKS AS A GUIDANCE SOLUTION FOR AEROCAPTURE, HYPERSONIC ENTRY AND SOFT-LANDING

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ABSTRACT

In the past few years, Astrium Space Transportation has demonstrated its capabilities on Entry, Descent and Landing Systems: the Atmospheric Re-entry Demonstrator (ARD) operated a successful hypersonic re-entry and was recovered in the sea after a final parachute descent, Phoenix perfectly performed an auto-landing on Earth and productive partnerships were also led on planetary exploration missions such as Huygens.

Furthermore, in-house studies have been led on various missions either on Earth or Mars, involving aeroassisted maneuvers for orbiters such as aerocapture, guided hypersonic entry and controlled powered descent with a hazard avoidance function for entry and descent vehicles. In this framework, extensive studies on Guidance, Navigation and Control (GNC) techniques and more specifically on guidance methods have been carried out. Among all different explored and designed guidance algorithms, an innovative technique using neural networks seems quite promising for the three applications (aerocapture, hypersonic entry and soft-landing).

Neural networks have been successfully applied to a wide range of domains such as financial, medical, electronics, defense, robotics... In the aerospace domain, they are also used for aircraft control systems, simulation or fault detection. Neural networks are especially valuable to handle problems with no analytic solutions. This is typically the case when confronted to the guidance of an atmospheric flight. Usually, when facing this type of problem, one makes strong simplifications to be able to determine a satisfactory command law. These simplifications, however helpful, usually lead to a non-optimal resolution of the guidance problem. Neural networks proved to be an interesting alternative as a more optimal guidance scheme.

At the end of a training process, the "neural guidance" is able to deal with the complete guidance problem, whether it be the management of the progressive braking of a lander as well as its lateral maneuvering or the management of the bank angle of a entry vehicle so as to accurately reach the target at the Mach 2 gate.

The poster describes the performance for typical aerocapture, hypersonic entry and soft-landing applications on Mars. This performance was assessed through closed loop simulations carried out with representative simulation tools involving models and associated dispersions on both vehicle design (propulsive features, mass, inertia, aerodynamics) and environment (initial conditions, atmosphere density, winds).